LOCOMOTION OF THE LARVA OF CALOSOMA SYCOPHANTA.*

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Among the interesting data in the report on "The Gypsy Moth," by Forbush and Fernald, which was published by the Massachusetts State Board of Agriculture in 1896, will be found a record of a series of experiments to determine the distance which young gypsy moth caterpillars will travel. Seven caterpillars were used, and it was found that the distance they crawled before dying ranged from 36 to 144 feet. Another record of experiments conducted with another insect is given on page 23 of bulletin 72 of the New York State Museum, which is bulletin 19 on entomology, published in 1903. In it Dr. Felt writes concerning the grape root worm that he carried on "some experiments to determine the burrowing and traveling power of these little creatures. One small grub was placed on a piece of paper at 9.27 in the morning and its wanderings were carefully traced with a pencil till 4.43 in the afternoon. The little creature traveled almost continuously during the entire period and showed a decided tendency to turn to the left. It covered the relatively enormous distance of over 47 feet in seven hours, or an average of about 2 yards an hour. The grub was placed in a dry vial and under such unfavorable conditions lived about three days."

These experiments show that insect larvae are able to survive for a much longer time than would be expected, and to do so under adverse conditions. The ability to travel until food is secured being absolutely necessary to the existence of the individual this factor plays a very important part in determining the ability of larvae to survive, and especially is this true of predaceous forms. Our attention was strongly directed to this matter in connection with the work of importing and colonizing certain predaceous enemies of the gypsy and brown-tail moths in Massachusetts. The ability of the larvae of *Calosoma sycophanta*, a predatory species which has been received from Europe, to travel any great distance in search of food is of para-

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mount importance to the well-being of the species, and although the insects had been found to be very active in breeding jars it seemed worth while to secure more accurate data as to their powers of locomotion. Accordingly, a set of experiments was planned to determine the distance that a larva of this species would travel from the time of hatching until it died, provided no food or moisture was supplied. In order to carry out the test it was necessary to do so under conditions which never occur in nature, but the results indicate the practical impossibility of carrying on tests over so long a period unless absolute control is secured, so that a careful record can be made.

The following apparatus was used (Plate XIII): A small table 3 ft., 8 in. long, by 2 ft. wide was provided with spools at each end near the top, so that a roll of paper could be reeled across the top of the table, the result being accomplished by turning the spools. Beneath this paper was placed a piece of stiff wrapping paper which extended beyond the sides of the paper connected with the reels, and the edges were bent upward in such a manner as to prevent the escape of the larva from the sides of the table. The paper on the reels was ordinary wrap-

Fig. 1. Rolls of Records.

A. F. Burgess.

ping paper 18 inches wide. The larva was placed in the center of the table and a record of its travels was made with a lead pencil.

At 8:30 A. M., June 18, a newly hatched larva was placed in the center of the table by Mr. C. W. Collins, and the record was kept throughout the day with the assistance of Mr. R. G. Smith. The table had been placed in an attic room in the laboratory, having only one window, which was on the west side of the house. During the day the larva moved rapidly away from the light, and when it had reached the end of the roll the table was turned end for end and the insect began traveling in the opposite direction. Although there were forty yards of paper on this roll, it was necessary at 1 P. M. to remove the larva and substitute a fresh roll, as it had crossed the paper from end to end five or six times.

The complete record of the travel of this larva required 11 rolls of paper and one assistant and sometimes two, depending on the activity of the insect, had to be constantly at work. (Fig. 1.) The experiment was carried through continuously until the larva died, and the extraordinary vitality which it exhibited, promised, at one time, to exhaust the supply of assistants that could be spared for the work.

The following table gives the data secured from the record on each roll.

Time	Total	Distance	Rate per min.
8.30 a. m. to 1 p. m.	4½ hrs.	1323.63 ft.	4.9 ft.
1 p. m. to 4.40 p. m.	3 2-3 hrs.	719.40 ft.	3.27 ft.
4.40 p. m. to 9. 40 p. m	5 hrs.	1213.14 ft.	4.04 ft.
9.40 p. m. to 1.45 a. m.	4½ hrs.	1164.51 ft.	4.75 ft.
2 a. m. to 8 a. m	6 hrs.	733.17 ft.	2.03 ft.
8.40 a. m. to 11.40 a. m.	3 hrs.	926.03 ft.	4.03 ft.
11.54 a. .m to 4.40 p. m.	4 23-30 hrs.	933.15 ft.	3.26 ft.
5 p. m. to 10.15 p. m.	5¼ hrs.	712.15 ft.	2.26 ft.
10.35 p. m. to 2.05 a. m.	3½ hrs.	575.91 ft.	2.74 ft.
2.15 a. m. to 1.30 p. m	11½ hrs.	766.5 ft.	1.13 ft.
1.30 p. m. to 8.45 a. m	19¼ hrs.	190.44 ft.	.16 ft.

The larva remained alive from 8:30 Saturday morning until 8:45 Tuesday morning, 72 hours, and was active the greater part of the time. It was necessary to place the insect in a glass each time a new roll of paper was attached, so that the entire length of time that the larva was actually on the paper was about 70 hours. The table gives the distance traveled during different periods, the total amounting the 9,058 feet, or 1.71 miles.

The highest rate of travel per minute was during the first 4½ hours, and averaged 4.9 ft. For the first 24 hours the average was 3.69 ft. per minute; during the next 8 hours the average dropped slightly and for the remaining period the average was gradually reduced until the larva died.

The temperature in the room where the experiment was conducted ranged considerably higher than that outside the building, the following records being taken from the report of the U. S. Weather Bureau at Boston.

June 18—	Maximum,	79 degrees;	Average,	70	degrees.
" 19—	"	75 "	"	68	"
" 20—	"	86 "	"	74	"
" 21—	"	92 "	"	80	"

The larva was kept continually on a dry surface, so that evaporation was very rapid, and doubtless reduced the length of time that the insect would have survived under normal conditions.

For the first 36 hours the larva traveled almost continuously, stopping only occasionally for a minute or so to rest.

During this time it traveled away from the light, viz., from the window during the day time, and at night away from the single electric light which was in the room. On the second night, which was after 36 hours of continuous travel the larva began traveling toward the light, and continued to do so during the night.

Mr. R. G. Smith, who was on duty at the time, noted that from 8 A. M. on June 20, the larva traveled at a continuously decreasing speed. Marks were made showing direction of travel, and every fifteen minutes the time was noted on the lines of travel. Resting periods: 4.32 P. M., 8 minutes; 4.45 P. M., 5 minutes; 5.15 P. M., 10 minutes; 5.46 P. M., 12 minutes; 6.36 P. M., 4 minutes; 6.42 P. M., 7 minutes. The larva moved only several inches at a time. In the morning the larva rested often, but only for a few minutes at a time. Mr. J. J. Culver noted that about 11 P. M., June 20, the larva began to crawl backwards, at intervals bending the head down as if trying to bite itself. It would do this for two or three minutes, then either rest or crawl in the normal manner. At this time the larva had become either insensible to light, or too weak to continually travel from it, as it traveled toward the light as much, if not more, than from it. In backing the larva always moved from the light.

At 12.45 A. M., the larva was very weak, it had scarcely moved during the last hour, and remained in a humped-up position. If touched with a pencil point, it would jump, but would not move either forward or backward. Between 8.25 P. M., June 20, and 1.40 A. M., June 21, the larva rested 4 hours, 15 minutes.

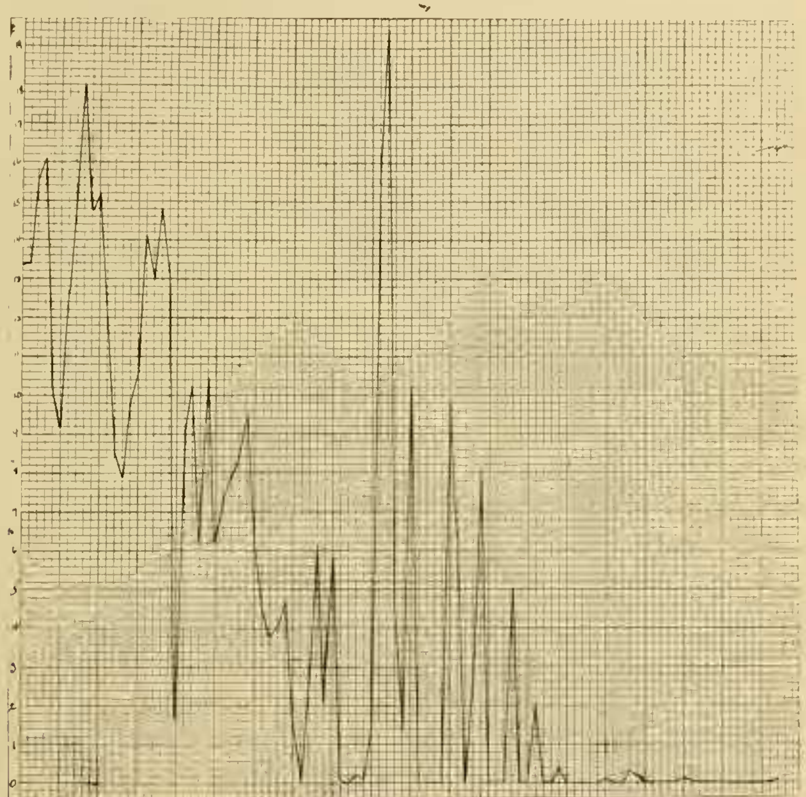

FIG. 2. Distance traveled by larva during the last twenty-four hours. Figures at left indicate number of feet each small horizontal space indicates a fifteen minute interval.

Mr. H. E. Smith, who was on duty at the time, noted that the larva did not move from 1.45 A. M. to 2.30 A. M., when it backed ¼ of an inch, remaining thus until 3.25 A. M., when it turned half way round in its tracks. The line from 1.45 A. M. to 4 A. M. was all backed over, except in a small circle which was traveled in the normal manner. At 3.55 A. M. the larva fell on its back and remained so until 4.05 A. M. when upon being touched in order to test life it grappled the lead pencil point and again regained its footing. It moved and backed in a small circle at 5.15 A. M. At 7.05 A. M. it fell on its back again, and remained there until it died at 8.40 A. M., June 21.

The rate of travel from 8.30 A. M., June 20, to 8.40 A. M., the following morning, which was the last twenty-four hours of the insect's life, is shown in the diagram (Fig. 2.) and illustrates how remarkable was the activity until almost the close of its life.

No delicate balances were available for weighing the larva after it hatched, but as soon as it died it was weighed by Mr. W. G. Fall, of the Massachusetts Department of Weights and Measures in Boston. The average weight of ten newly hatched larvae was .2973 grains; the weight of the dead larva was .18 grains, which indicates that it lost .1173 grains during the experiment.

Although the distance traveled is probably much greater than what would actually occur in nature, it is remarkable that so much latent energy can be stored up in an egg of one of these beetles. It is interesting to compare the ability to travel possessed by this larva with that of some of the higher animals. Through the courtesy of Dr. W. E. Castle and his assistant Mr. Detlefson, of the Bussey Institution, of Harvard University, we have been able to secure measurements and weights of young rats and guinea pigs and this information is used in making the comparison. The average length of all the legs of the larva of *Calosoma sycophanta*, ten specimens having been measured, was 3.37 mm., that of a young rat, one to three days old twelve specimens having been measured, was 19.08 mm., or 5 2-3 times greater, while similar measurements of a guinea pig showed that the average length of leg was 76.25 mm., or 22½ times greater than that of the beetle larva. If the ability to travel of the higher animals mentioned equalled that of *sycophanta*, the rat would be able to cover nine miles without food or water, while the guinea pig would have to cover over 38 miles under the same conditions. It might be said that the locomotive powers of a young guinea pig are superior to that of a rat of the same age but doubtless either would die before traveling a very short distance to obtain food.